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# European Union Emissions Trading Scheme (EU-ETS) Futures Liquidity Effects: Evidence from the European Energy Exchange (EEX)

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## Abstract

We examine liquidity effects after the onset of trading in phase II of the EU-ETS for European Union Allowance (EUA) futures contracts. We obtain evidence of long-term improvement in liquidity of the EEX EUA December 2008 futures contract after the commencement of trading in phase II. Our results suggest the application of a new regime of trading rules in Phase II led to the improvements in liquidity.

**Keywords:** Abnormal returns, Liquidity, Carbon trading, Climate change, EU-ETS, EUA

**JEL Classifications:** G10, G14, G18

## 1. Introduction

The European Union (EU) consented under provisions of the Kyoto Protocol to reduce its green house gases (GHG) emissions by 8% below 1990 base-year levels. In 2003, the EU Council provided the legislation to achieve this target through a council directive<sup>1</sup>. The EU-ETS was developed as the principal policy instrument to achieve the EU's obligations under the Kyoto protocol. The scheme came online in 2005 and has since grown to become the world's largest carbon market. In 2009, the scheme accounted for 96.46%<sup>2</sup> of global allowances trades. This is with a trading volume of about 6.326 billion tonnes of CO<sub>2</sub> (tCO<sub>2</sub>) worth US\$118.5 billion, up from approximately 3.1 billion (\$101.49 billion) tonnes in 2008 (see Capoor and Ambrosi, 2008; Kosoy and Ambrosi, 2010).

Increasingly, emissions' trading is proving to be the preferred policy option in achieving emissions reductions. The rapid growth of the EU-ETS and the increasingly important position it occupies in the drift towards combating climate change has elicited the interest of industry experts and academics alike (see Daskalakis and Markellos, 2008; Daskalakis *et al.*, 2009; Frino *et al.* 2010; Montagnoli and de Vries, 2010; Zhang and Wei, 2010; Daskalakis *et al.* 2011 among others).

Some other Annex B nations have followed the EU's cue in setting up a cap and trade scheme, while others are pursuing appropriate legislations to establish the scheme. New Zealand has passed the Climate Change Response Amendment act, in Australia, although the Carbon Pollution Reduction Scheme (CPRS) is on hold, the Renewable Energy Target (RET) scheme is gathering pace. In both Japan and the United States, local and state government authorities have in anticipation of national cap and trade schemes commenced local GHG reduction programmes.

With the dominance of the EU-ETS, recent events suggest that governments in other regions of the world are already towing the line of the EU on emissions trading. In the event that a global ETS is fashioned, as it should in order to effectively counter climate change, the scheme will be anchored on the EU-ETS infrastructure. As an indication of developments in the future, three non-EU countries: Liechtenstein, Norway and Iceland have already linked their cap and trade structures to the EU-ETS. The provisions of the New Zealand ETS also consider this a possibility. Creating a mesh of linkages of various ETS structures around the globe will likely precede a global ETS and the EU-ETS is the dominant anchor that can provide the required liquidity for that.

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<sup>1</sup> Directive 2003/87/EC.

<sup>2</sup> This figure is based on value of carbon instruments traded on cap and trade schemes. The total global value for this period was \$122.8billion.

Butzengeiger *et al.* (2001) identified *liquidity* as a precondition for the success of an ETS. The scheme should involve a sufficient pool of participants to ensure adequate volume of transactions on a regular basis; this results in the emergence of an explicit price signal to the market. Beyond market considerations, fragmentation of platforms can inhibit advancement of liquidity especially in new nascent markets like the carbon market. Liquidity risk resulting from fragmentation of trading platforms is a fundamental risk in the EU-ETS (Hill *et al.* 2008).

Given the importance of liquidity to the success of the EU-ETS and by extension, the success of a global cap and trade scheme; the liquidity effects of the December 2008 EEX EUA futures contract is investigated.

Three daily measures of liquidity are applied. The quoted spread is constructed, this is the difference between the best ask and best bid prices. The quoted bid-ask spread is vital because it is the measure of the compensation to the market maker for providing liquidity to the market (Branch and Freed 1997, Campbell *et al.* 1997, Sarr and Lybek 2002). The relative spread is also derived. The relative bid-ask spread is the difference of the best ask and bid prices divided by the average of both prices. The relative bid-ask spread is often viewed as an unreliable measure; this is because substantial volumes of trades in financial securities often transpires within the bid and ask prices<sup>3</sup>. (Lee and Ready 1991, Hedge and McDermott 2003). Lee and Ready (1991) also found that the measure potentially overestimates the costs of securities by not considering the propensity of price increases after a buy order has been satisfied and price decrease after a sell order.

To improve the study, the effective bid-ask spread is calculated after the methods used by (Heflin and Shaw 2000), Hedge and McDermott (2003) and (Gregoriou 2010). The Effective bid-ask spread is twice the absolute value of the prevailing transaction price and the daily best mid-price.

The remainder of this paper is arranged as follows: Section 2 discusses the trading mechanism of the EU-ETS. Section 3 reports on the data and methodology. In section 4, the results are presented; section 5 provides a summary/conclusion of the findings.

## **2. Trading and trading mechanism in the EU-ETS**

One European Union Allowance (EUA) grants the holder the right to emit one tonne of CO<sub>2</sub>. By capping the volume of EUAs created, a limit is thus placed on the volume of CO<sub>2</sub> emissions that can be emitted during the period. The first two phases of the EU-ETS were aimed at regulating solely the emission of CO<sub>2</sub>. About 12,000 installations with minimum generating capacity of 20 megawatts (MW) in a number of sectors within the EU are participants<sup>4</sup>. Combined, these installations account for approximately 40% of the EU's total GHG emissions and about 50% of its CO<sub>2</sub> emissions (Hawksworth and Swinney 2009). EUAs are electronically generated as records on the registries established by each member state of the EU. Consequently, EUA can be regarded as a commodity in several contexts including in its delivery as an underlying of derivative contracts. Delivery of EUAs is thus virtually *risk-free* in comparison with more traditional commodities such as agricultural products, petroleum products etc. (Daskalakis *et al.* 2011).

All EU national registries are linked and are connected to the Community Independent Transaction Log (CITL), which chronicles all changes to EUA rights by stakeholders at both national and continental levels. Consequently, the national registries record of firm level trading activities is replicated on the CITL as every trade within a member state is registered at the relevant national registry. Annually, reconciliation of emissions positions occurs and defaulters fined in addition to delivering the missing EUAs.

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<sup>3</sup> Approximately 98% of the trades in the final sample occurred within the spread.

<sup>4</sup> These sectors include electricity generators, mineral oil refineries, coke ovens, ferrous metals, glass, ceramic products and cement manufacturers to glass and pulp producers. Electricity generators are however the leading CO<sub>2</sub> emitters. By Council decision, from 2011 onwards the aviation sector will be included in the EU-ETS (Directive 2008/101/EC).

Since inception, futures trading has accounted for the bulk of transactions on the EU-ETS. In 2009, 73% of all transactions were in carbon futures; spot, 23% and approximately 5% in options even as spot and options trading recorded a year on year increase of 450% and 70% respectively (Kossoy and Ambrosi 2010). Daskalakis *et al.* (2009) examined this phenomenon regarding the dominance of futures in the EU-ETS, especially since derivatives only develop as appendages to the underlying security in most financial markets. The authors opined that EUAs are needed for deletion only on an annual basis, therefore there is little advantage in holding on to them for the duration of the year, positions can however, be taken in the futures market to the advantage of the traders as required during the year. Further, in commodities markets, it is not unusual for derivatives trading to mature quicker than the underlying, as has been the case with the EU-ETS, hence most of the current research has focused on derivatives.

### 2.1. *Trading on the European Energy Exchange (EEX)*

The EEX runs commodity trading platforms on Natural gas, Emission allowances, Coal and Power with over 300 participants all over mainland Europe and up to three from the United States. It is reputed to be the largest energy exchange in Europe<sup>5</sup>.

The EEX currently offers trading in emission allowances spot and derivatives. The underlying for each futures contract on the EEX is 1,000 EUA (1,000tCO<sub>2</sub>). There are technically two delivery dates in December: Early and Mid-December. Early December delivery was the only delivery date in use during phase I, but in phase II, the mid-December date was introduced and trading has since exclusively been on the mid-December contracts. Electronic trading continuously takes place throughout the hours of 0900hrs and 1700hrs Central European Time on trading days. Prices are quoted in Euros with a minimum tick of €0.01 per tCO<sub>2</sub>. Electronic trading perhaps is the best option for the EEX in view of the low daily trading averages. In more conventional markets, the introduction of electronic trading with market makers has been found to have greatly improved liquidity (see Barclay *et al.*, 1999; Domowitz, 2002; Gregoriou, 2010). Trading volume on the EEX has in recent months advanced rather rapidly. This is due to the decision of Europe's largest CO<sub>2</sub> emitter, RWE AG to shift some of its carbon trade from the ECX to the EEX (Carr 2010).

## 3. Data and Methodology

### 3.1. *Data*

Analysis of liquidity effects of the transition between phase I and phase II of the EU-ETS on the December 2008 contract is undertaken. The contract chosen for the event is based on the following conditions:

1. The contract has historical data on the EEX for a period of 90 days before and after the event.
2. The contract is the most actively traded contract on the EEX 90 days before and after the event<sup>6</sup>.

Data sources are the European Energy Exchange (EEX) and the London Energy Brokers Association (LEBA). Daily data spanning 4<sup>th</sup> October 2005 to 30<sup>th</sup> December 2010<sup>7</sup> is employed.

### 3.2. *Methodology*

Analysis commences by conversion of calendar time to event time (see Beneish and Gardner, 1995 and Gregoriou and Ioannidis, 2006). 2<sup>nd</sup> January 2008 is defined as event day 0. This is the first day of trading in phase II. Event study as outlined in Campbell (1997) using the basic market model is employed<sup>8</sup>. The market model has been established by several studies (see Brown and Warner, 1985; Hedge and McDermott, 2003; Denis *et al.*, 2003; Gregoriou and Ioannidis, 2006).

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<sup>5</sup> See [www.eex.com/en](http://www.eex.com/en).

<sup>6</sup> Scarcity of transactions such that at any one period only one or two contracts were sufficiently traded are observed, hence events are examined using the most actively traded contract at the period during which the event occurred.

<sup>7</sup> A sample of all trading contracts during this period is retained to provide a view of platform-wide liquidity changes over the two phases. The December 2008 contract matures on 28<sup>th</sup> November 2008.

<sup>8</sup> Another option is the constant mean return model. Some authors have found the results from the use of both methods, quantitatively similar (see Campbell *et al.*, 1997; Gregoriou and Ioannidis, 2006)

The model assumes a linear relationship between the return of an instrument with its value-weighted market index. The LEBA carbon price index is adopted as the required value-weighted index. This is used in estimating the model parameters over 90 days prior to the events<sup>9</sup>. Excess returns for each trading day in the event windows are obtained and aggregated through time to obtain cumulative abnormal returns (CAR) for each window investigated. Average abnormal returns (AAR) for each event window are presented in Table 2.

## 4. Empirical Results

### 4.1. Descriptive statistics

Table 1 reports the summary statistics for the market liquidity proxies and trading activity measure of daily traded volumes. The evidence points to higher intertemporal fluctuations in daily volume than the liquidity proxies; this is implied by the higher coefficients of variation. The reason for this can be down to the fact that bid and ask prices are essentially discrete variables; this property helps in diminishing the potential for volatility through price clustering (Chordia *et al.* 2001). Further, values of the effective bid-ask spread reflect that a considerable number of trades took place within the spreads.

#### Panel A

	Quoted Spread (€)	Relative Spread	Effective spread (€)	Daily volume (contracts)
<i>Mean</i>	46.31%	3.62%	32.87%	46.26
<i>Standard Deviation</i>	0.222748	0.030683	0.2848	81.80315
<i>Coefficient of variation</i>	0.518018605	1.17110687	1.1392	8.180315
<i>Median</i>	43.00%	2.62%	25.00%	10.00

#### Panel B

	Quoted Spread	Relative Spread	Effective spread	Daily volume (contracts)
<i>Mean</i>	13.48%	0.77%	19.74%	269.56
<i>Standard Deviation</i>	0.075235	0.003315	0.194533	359.7729
<i>Coefficient of variation</i>	0.626958333	0.447972973	1.496407692	2.635698901
<i>Median</i>	12.00%	0.74%	13.00%	136.50

**Table 1.** The panels provide descriptive statistics for daily bid-ask spread values for EEX EUA futures contracts trading on the EEX platform between 4<sup>th</sup> October 2005 and 30<sup>th</sup> December 2010. The data is split into phases I and II. Values are computed by obtaining the averages for each individual contract trading during the period and then cross-sectionally aggregating across the range of contracts.

Each EUA futures contract has an underlying of 1000 tonnes of CO<sub>2</sub>. Excluding discarded dates, the panels contain data for 1,280 trading days.

### 4.2. Abnormal returns of Events: December 2008 contract

Abnormal returns and liquidity changes around the onset of trading in the new phase over an eleven day window (+5, -5) are examined. Results in Table 3 suggest the onset of trading in phase II did not

<sup>9</sup> See <http://www.leba.org.uk/documents/LEBA-EUA-Index-Specification.pdf> for computation details.

significantly alter the EEX EUA December 2008 contract returns although the abnormal returns (AR) are positive on the short term. On the long term, the abnormal returns are negative and also not significant. According to Campbell *et al.* (1997), the large  $R^2$  values obtained in the model estimation indicate corresponding variance reduction thereby leading to gain in model specified<sup>10</sup>.

Event window	AAR (%)	T-test $H_0: AAR=0$
[-1, +1]	0.48	1.02
[-2, +2]	0.36	1.23
[-3, +3]	0.29	1.27
[-4, +4]	0.08	0.36
[-5, +5]	0.0002	0.001
[0, +10]	-0.25	-0.98
[0, +20]	-0.31	-0.71
[0, +30]	-0.10	-0.3
[0, +60]	-0.04	-0.19
[0, +90]	-0.02	-0.12
Adjusted $R^2$	0.81	

\*\* Significant at 5% level

**Table 2.** Average Abnormal Returns (AAR) are computed using the market model for an event study aimed at determining excess returns on the EEX EUA December 2008 contract around the first day of trading in phase II of the EU-ETS. The estimation window for estimating the model parameters is 90 days before and after the events (-90, +90). AAR is then tested for significance using a regular t-statistic. T-statistics are reported along with the AAR values.

#### 4.3. Impact of events on trading volumes: December 2008 contract

Test for variations in trading volumes around the start of trading in the phase II of the EU-ETS using EEX EUA December 2008 futures contract is undertaken by estimating the dummy variable time series regression model (1).

$$Volume_t = \alpha + \sum_{-5}^{+5} D_i \beta_i + \varepsilon_t \quad t = -90, +5 \quad (1)$$

Where  $Volume_t$  corresponds to the logarithm of the trading volume for day  $t$ .  $\alpha_t$  captures the trading volume variations over the 96 day estimation period and  $D_i$  are dummy variables representing each day in the investigated event window (-5, +5). The coefficients of all eleven dummy variables encapsulate the variations in trading volume over the event window (Gregoriou, 2010; Hedge and McDermott, 2003)<sup>11</sup>.  $\varepsilon_t$  is a residual term with  $E[\varepsilon_t] = 0$  and  $Var[\varepsilon_t] = \sigma^2$ .  $\alpha$  and  $\beta_i$  are parameters for estimation. The regression model (1) is estimated by Least Squares method using White's (1980) heteroscedastic consistent covariance matrix. The results are presented in Table 3.

Ten of the eleven dummy variables are positive and significant, evidencing a considerable increase in trading volume as a result of the onset of phase II. The evidence is strengthened by the fact that January 2<sup>nd</sup> and 3<sup>rd</sup> 2008 (the first and second days of trading in phase II) have the highest values in the 11-day period examined with 2.27 and 2.28 respectively. They have respective t-statistic of 10.82 and 10.87, values significant at 5% levels. After the 3<sup>rd</sup> of January 2008, the abnormal volume decreases from the peak values but remained positive and significant at 5% level.

<sup>10</sup> This is a major advantage of the market model over the constant-mean-returning model as a normal performance model.

<sup>11</sup> Hedge and McDermott (2003) found that trading volume may increase over time on the New York Stock Exchange (NYSE) and Gregoriou (2010) showed significant and positive abnormal volumes on the London Stock Exchange (LSE).

Parameter	Estimates	T-Statistic
$\alpha$	3.00	14.33**
$\beta_{-5}$	1.55	7.39**
$\beta_{-4}$	1.70	8.09**
$\beta_{-3}$	1.09	5.20**
$\beta_{-2}$	-3.00	-14.33**
$\beta_{-1}$	0.91	4.33**
$\beta_0$	2.27	10.82**
$\beta_{+1}$	2.28	10.87**
$\beta_{+2}$	1.90	9.06**
$\beta_{+3}$	1.42	6.75**
$\beta_{+4}$	1.38	6.57**
$\beta_{+5}$	1.94	9.24**
$R^2$	0.12	
NORM (1)	0.17	

\*\* Significant at 5% level

**Table 3.** The time series regression model (1) is estimated to examine trading volume changes around the first day of trading in phase II of the EU-ETS using the December 2008 EEX EUA futures contract. The estimates are reported along with corresponding t-statistics. NORM (1) is the p-value for the Jarque-Bera normality test.

#### 4.4. Liquidity improvements: December 2008 contract

Finally, to examine the effect of the onset of trading in phase II of the EU-ETS, ratios of the daily average quoted, relative and effective bid-ask spreads are computed following Gregoriou (2010). The issue with the use of the two latter measures is the inevitability of increases owing to rise in mid-price as a result of the onset of trading in phase II<sup>12</sup>. Phase II NAPs provide lesser EUA allocations than Phase I, creating scarcity and driving up prices. For this reason the quoted bid-ask spread ratios are included in the results. Spread ratios for each day in the windows are computed as the ratio of the average bid-ask spread measure for the event window to the average bid-ask spread value over the pre-event trading period (0, -90). A regular t-statistic is used in testing the  $H_0$  that there were no liquidity changes between the pre-event period (90 trading days) and the event windows. Results are reported in Table 4. There is profound evidence of substantial narrowing of spreads after the onset of trading in phase II. As an example the mean and median quoted bid-ask spread ratios for event window (-1, +1) are 0.74 and 0.73 respectively, the decrease to 0.59 and 0.55 over the (-5, +5) event windows evidences considerable narrowing of the spreads. All values are highly significant at 5% levels. The narrowing is even more pronounced for the relative and effective bid-ask spread measures due to the mostly positive abnormal returns shown in Table 2 as a result of price appreciations after the onset of trading in phase II. The significant further narrowing of the spread measures in the long-term event windows suggests that the easing of transaction costs is permanent.

<sup>12</sup> Positive abnormal returns in Table 2 evidence price improvements as a result of the price appreciations.

Event window	Quoted spread ratios Mean (Median)	Relative spread ratios Mean (Median)	Effective spread ratios Mean (Median)
[-1, +1] T-test	0.74 (0.73) -2.25**	0.70 (0.67) -2.82**	0.43 (0.37) -9.23**
[-2, +2] T-test	0.60 (0.55) -3.49**	0.57 (0.53) -3.99**	0.35 (0.37) -10.70**
[-3, +3] T-test	0.59 (0.55) -4.71**	0.56 (0.53) -5.23**	0.35 (0.37) -14.91**
[-4, +4] T-test	0.59 (0.55) -5.07**	0.56 (0.53) -5.55**	0.32 (0.30) -15.92**
[-5, +5] T-test	0.59 (0.55) -5.34**	0.56 (0.53) -5.82**	0.34 (0.30) -12.92**
[0, +10] T-test	0.40 (0.33) -8.68**	0.37 (0.30) -9.62**	0.45 (0.37) -4.83**
[0, +30] T-test	0.40 (0.29) -12.97**	0.41 (0.30) -12.17**	0.56 (0.41) -4.58**
[0, +60] T-test	0.33 (0.25) -25.58**	0.33 (0.26) -24.23**	0.47 (0.37) -9.43**
[0, +90] T-test	0.30 (0.25) -36.96**	0.30 (0.26) -35.23**	0.43 (0.26) -13.25**

\*\* Significant at 5% level

**Table 4.** Changes in EU-ETS liquidity in response to the first day of trading in phase II of the EU-ETS are examined using the quoted, relative and effective bid-ask spreads of the EEX EUA futures contracts for December 2008 delivery. The ratios are constructed to compare liquidity of the selected futures contract in the period before the events (-90) and various event windows around the event dates. The quoted bid-ask spread is the difference between the daily best ask and bid prices, the relative bid-ask spread is the daily ask price minus the best bid price divided by the daily best mid-price, effective bid-ask spread is twice the absolute value of the prevailing transaction price and the daily best mid-price. The spread ratios are calculated as the ratio of the average spreads of selected contracts over the relevant event window to the average of the spreads for the pre-event period (0, -90). A regular T-statistic is used to test the null hypothesis that the mean of the reported ratio for the contracts is equal to one.

## 5. Conclusion

The EU-ETS remains the largest carbon ETS. It is also not a finished article; it is fraught with threats of abuses akin to financial markets (see Diaz-Rainey *et al.*, 2011). The European Commission, the EU Council and Parliament are continuously drafting new regulations/policies in response to the current operational issues arising from the activities on the various platforms. It is currently responding to hacking threats that saw more than €30 million worth of emissions permits stolen from some of the national registries in January 2011<sup>13</sup>. This singular event underscores more than any before it, the increasing value of the EU-ETS.

This paper shows evidence of improvements to liquidity between phase I and phase II of the EU-ETS. The improvement is not linked to significant increase in price of futures contracts. Further evidence that this improvement endures for the long term (90 trading days in the sample) is provided. These results contain some policy implications: The changes to trading rules for phase II in response to the fault lines observed in phase I<sup>14</sup> evidently improved market confidence as shown by the advancement of market quality and trading volumes in this study.

<sup>13</sup> See <http://www.ft.com/cms/s/0/cdb788e8-24df-11e0-895d-00144feab49a,s01=1.html#axzz1HXNlcFmW>

<sup>14</sup> These include regulations on banking, borrowing etc. (see Daskalakis *et al.*, 2011).



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